Before the
Federal Communications Commission
Washington DC 20554

In the Matter of	**)**	
	)	
Unlicensed Use of the 6 GHz Band	**)**	**ET Docket No. 18-295**
	)	
Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz	**)**	**GN Docket No. 17-183**

To: The Commission

COMMENTS OF THE CRITICAL INFRASTRUCTURE COALITION

MidAmerican Energy Company
PacifiCorp
NV Energy
Black Hills Corporation
Salt River Project Agricultural Improvement & Power District
Exxon Communications Company
NorthWestern Energy
Enterprise Products Partners L.P.
GeoSouthern Energy Corporation
Louisville Gas and Electric Company
Kentucky Utilities Company
Marathon Oil Corporation
Occidental Petroleum Corporation

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SUMMARY OF ARGUMENTS

For decades, the members of the *Critical Infrastructure Coalition* have relied on the 6 GHz band to provide backhaul communications links which connect essential services like electric utility teleprotection systems, utility and energy field SCADA systems, enterprise network field connectivity, oil and gas pipeline control systems, and land mobile voice communications systems. These systems seamlessly function 24 hours a day, 7 days a week, 365 days a year to meet the energy demands of Americans. The *Coalition* has no reasonable alternative to the 6 GHz band for these communications systems. The Commission now proposes to change its rules to permit unlicensed operations in this band, which could introduce harmful interference to essential services and, in turn, compromise a variety of vital energy field and utility operations.

The *Coalition* appreciates the Commission's need to provide more unlicensed wireless spectrum to support broadband deployment, but its proposals will not adequately protect fixed incumbent 6 GHz licensees. The Commission should protect incumbent fixed licensees from harmful interference by adopting rules that limit unlicensed users in the band. The Commission should adopt an interference criterion proposal of 1 dB fade margin degradation (I/N = -6 dB). Finally, the Commission should require prior coordination for all indoor and outdoor unlicensed operations. The Commission should not move forward with its proposals if it cannot ensure 6 GHz point-to-point systems will be fully protected.

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MidAmerican Energy Company, PacifiCorp, NV Energy, Black Hills Corporation, Salt River Project Agricultural Improvement & Power District, Exxon Communications Company, NorthWestern Energy, Enterprise Products Partners L.P., GeoSouthern Energy Corporation, Louisville Gas and Electric Company, Kentucky Utilities Company, Marathon Oil Corporation, and Occidental Petroleum Corporation, (collectively, "the *Critical Infrastructure Coalition*" or "*Coalition*"), by their attorneys and pursuant to Sections 1.415 of the Rules of the Federal Communications Commission ("FCC" or "Commission"),[1] submit these Comments in response to the Notice of Proposed Rulemaking released in this proceeding on October 24, 2018 ("NPRM").[2]

[1] 47 C.F.R. § 1.415.

[2] *Unlicensed Use of the 6 GHz Band*, Notice of Proposed Rulemaking, ET Docket No. 18-295 (rel. Oct. 24, 2018) ("*NPRM*").

I. BACKGROUND

A. History of the 6 GHz Band

The 6 GHz band is divided into several sub-bands, including the U-NII-5 (5925-6425 MHz) and U-NII-7 (6525-6875 MHz) portions of the 6 GHz band. The U-NII-5 portion of the band is currently allocated in the United States exclusively for non-Federal use on a primary basis for fixed satellite service (earth-to-space) and terrestrial fixed service.[3] The U-NII-7 portion of the band is also heavily used for fixed terrestrial service. The FCC's rules allow licensees to operate point-to-point microwave links with up to 120 MHz of paired spectrum for each authorized path. More than 27,000 licenses are used for point-to-point operations in this band. The FCC acknowledged in its Notice of Inquiry and NPRM that fixed terrestrial service operations in the 6 GHz band "support a variety of critical services such as public safety (including backhaul for police and fire vehicle dispatch), coordination of railroad train movements, control of natural gas and oil pipelines, regulation of electric grids, and backhaul for commercial wireless traffic."[4]

The 6 GHz band is robustly used throughout the country for fixed point-to-point services that support the public safety and other critical needs. Despite this, the Commission now proposes to change its rules to permit unlicensed operations in this band.[5] Such changes threaten the integrity of these existing operations.

[3] *In the Matter of Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz*, 32 FCC Rcd 6373 at ¶24 (2017) ("*Mid-Band NOI*"); *NPRM* at ¶9.

[4] *Id.* at ¶25.

[5] *NPRM* at ¶22 *et seq*.

II. COMMENTS

A. The *Coalition's* Use of the 6 GHz Band

The *Coalition* collectively holds more than 600 licenses authorizing the operation of fixed point-to-point microwave systems in the U-NII-5 (5925-6425 MHz) and U-NII-7 (6525-6875 MHz) portions of the 6 GHz band. More information about the *Coalition* members is included in Exhibit A. Coalition members use their fixed point-to-point microwave systems for a diverse array of critical communications services. These services are essential to the ongoing operation of their underlying business and promote safe and efficient day-to-day operations. The *Coalition* members specifically rely on 6 GHz licensed spectrum for these critical communications because of the band's reliability and the protection from interference afforded the licensees by the frequency coordination process. Many of these licensed systems have been operated for decades.

The utility members of the *Coalition* rely on the 6 GHz band to support the transmission and distribution of electricity and the distribution of natural gas and water to more than seven million Americans. These licensed microwave links provide communication between power substations, dams, power generating stations, central offices, and remote mountain-top locations where no telecommunications infrastructure exists. Similarly, the *Coalition's* oil and gas and midstream members rely on 6 GHz microwave radio networks to provide communications links between oil fields and central offices, remote monitoring systems for oil and gas and chemical storage, and pipeline control spanning thousands of miles. These vast multi-state networks provide connectivity between some of the most rural areas of the country and populous urban cities. Some links cover a distance of 70 miles.

The *Coalition's* members use 6 GHz licensed spectrum to transport data and voice communications such as Supervisory Control and Data Acquisition (SCADA) system data, land mobile voice communications, grid network monitoring systems for electric utilities, distribution automation systems for electric and water providers, and substation security surveillance systems, many of which are deployed across the companies' service territories and operate on other licensed spectrum bands. The data that is retrieved from these networks is critical to *Coalition* companies, providing daily production data, real-time data for digital oil field initiatives, data required for inclusion in applicable federal, state and local reports, and real-time information in support of operational decision making and safety event notifications.

The electric transmission grid and the infrastructure that supports oil and gas production and transportation across the country are heavily reliant on 6 GHz licensed spectrum. Electric transmission grids are comprised of transmission lines, transformers, and breakers. Utilities protect these components from damage by implementing teleprotection systems, which must maintain extremely reliable, low latency communications in order to monitor and control the balance of power on the grid. These relay system communications are supported by 6 GHz licensed spectrum, and any disruption of relay system communications during a fault event could result in significant damage to transmission system components costing millions of dollars in repair costs.

Land mobile radio systems are utilized for voice communications from power and water control centers and field crews, across vast oil fields in remote parts of the Midwest, and to the massive oil refinery and petrochemical plants along the Texas Gulf Coast outside Houston, Texas. These voice communications include switching operations on power transmission and distribution systems in which accurate communications are a crucial part of ensuring field crew

safety. They support daily oil field production and pipeline monitoring. These voice radio systems are also essential for recovery of damage to the power grid due to weather-related activities such as micro-bursts. Without 6 GHz backhaul support, these voice networks would be isolated from one another and from central office control.

SCADA systems allow the *Coalition's* utility members to monitor and control power and water systems from central control centers and remote field devices. Without accurate and reliable SCADA information, the *Coalition's* utility members cannot provide critical water and power services to their customers.

Similarly, the *Coalition's* oil and gas member companies use SCADA systems to support telemetry and pipeline measurement data systems, which include remotely monitoring tank levels, pipeline pressures, alarms and other various aspects of controlling and monitoring operational facilities. SCADA data is transmitted over fixed point-to-point 6 GHz networks from well sites to regional offices and in some cases from those regional offices to corporate headquarters. This information includes data for well site safety and event notification which ensures quick response to environmental and life critical events. SCADA systems also provide water gathering system line balancing to control flow and pressure, including pipeline leak detection, as well as water gathering peer-to-peer communications used to automate the water pipeline gathering system, down hole temperature, and pressure used in subsurface reservoir analysis. They also support oil and gas pipeline valve, pump, and compressor controls at compressor stations, crude pump stations, and along the entirety of the pipelines themselves. These functions rely on constant, seamless communications networks supported by fixed 6 GHz microwave links.

Electric transmission and distribution systems and oil and gas pipelines are heavily automated. 6 GHz back-bone networks allow utilities to facilitate remote control and automated switch operations on power distribution systems. These networks also allow for seamless communications between remote field offices and gas control polling servers, which are essential for the safe operation of pipelines.

In addition to field support services and automation and control functions, *Coalition* members use 6 GHz microwave transport networks to provide private, internal corporate Internet between and among their offices. These communications support daily business operations and include work and asset management, telephone voice communications, email, and Internet/intranet. These systems also support "one-call" data for field office locations, which allows *Coalition* members to receive notifications related to construction projects and seamlessly receive maps and photographs associated with the projects.

B. Critical Infrastructure Licensees Should Not Be Subjected to Harmful Interference

The 6 GHz microwave networks that the *Coalition* members rely on are designed to operate with extremely high reliability because of the critical nature of communications they transport. Many *Coalition* members deliberately chose the 6 GHz band for these critical operations because the FCC's rules governing frequency coordination have protected incumbent operations from harmful interference. This band has proven to be ideal for these systems, which require constant, uninterrupted communications. The Commission's proposal to introduce unlicensed operations in the 6 GHz band does not include sufficient protection to incumbent licensed operations. If the Commission does not adequately ensure that existing fixed point-to-point 6 GHz networks operated by *Coalition* members receive sufficient interference protection, the resulting impact of new unlicensed users could be catastrophic.

Interference to the 6 GHz communications systems described herein could, at a minimum, cause significant harm to the business operations of the *Coalition* members and result in costly expenditures and unplanned resource allocations. At worst, interference to these networks and loss of critical communications could jeopardize environmental safety and the well-being of the general public.

As discussed above, *Coalition* members use 6 GHz networks for real-time monitoring and control systems. If these companies even briefly lose connectivity, they will also lose valuable data and remote viewing and control capabilities. Accordingly, responses to environmental or safety events could go unnoticed for hours, impacting the ability to coordinate, control and timely address such an event. Extended interruptions could be far costlier, forcing the suspension of operations, like pipeline gas transport or residential power delivery, until networks could be restored.

Moreover, interference to existing fixed point-to-point 6 GHz networks could diminish a utility's ability to effectively operate electric and water systems and could cause instability in the power grid. Without these networks, restoration of distributed electrical service to residential and commercial customers during power outages can be encumbered. The Commission has frequently noted the impact of power outages to the general public and recently asked utilities how the agency could promote a more resilient infrastructure in the face of major storms.[6]

Some *Coalition* utility members transmit neighboring utility company data in addition to their own as part of cooperative communications agreements, meaning that a loss of 6 GHz communications to a single licensee due to interference from an unlicensed user could

[6] *See* Public Safety and Homeland Security Bureau seeks Comment on Improving Wireless Network Resiliency Through Encouraging Coordination with Power Companies, *Public Notice*, DA 19-13, (Rel. Jan. 3, 2019).

completely cut off automation and SCADA system control to entire communities, regardless of which utility is impacted by the interference.

Although *Coalition* members maintain backup communications systems for their primary 6 GHz networks, some of these backup mechanisms are dependent on local network equipment to determine whether backup paths need to be activated. Other backup systems are tied directly to the 6 GHz microwave equipment itself. The typical weak link in backup systems of this nature is that they are more designed for hard outages of primary communications paths. Interference from unlicensed users would likely result in path fading, not hard outages.

Path fading is the worst type of interference that transport systems with backup systems can experience. In many cases, it is impossible to design around radiofrequency interference that has variable duration, intensity, and levels of interference. Interference to these systems would likely appear as additional background noise and would degrade the signal-to-noise ratio, which in turn would lower the fade margin and reliability of the link. This level of background noise would likely not be enough to result in a hard outage, so instead of having backup systems automatically engage for a link, the system would remain online with high error rates and significant losses to incoming data. The negatively impacted microwave radio link would then likely need to be redesigned to achieve the same level of reliability. Link redesign could require installation of larger or higher-gain antennas, which could then lead to overloading existing tower infrastructure.

Several *Coalition* members had previously operated unlicensed systems, including in the 5.8 GHz, and 900 MHz ISM bands. Over time, these members have migrated to licensed point-to-point 6 GHz networks because the unlicensed bands were saturated with users. The legacy unlicensed systems received too much interference and proved unreliable. One *Coalition*

member recalled that in order to mitigate the interference, the company used its radio diagnostics capabilities to determine the next best alternate, interference-free, frequencies. It reconfigured its radios to those frequencies. But during this diagnostic period, the member's system experienced such detrimental interference that the underlying path was completely inoperable. All associated utility SCADA and high-speed system protection functions for the impacted sites were out of service until the path was restored. The Commission should ensure that, if unlicensed users are introduced into the 6 GHz band, this isolated problem does not become commonplace.

C. The *Coalition* Has No Reasonable Alternatives to the 6 GHz Band

The 6 GHz communications systems used by the *Coalition* are deployed across state lines and cover vast swaths of the country. The propagation characteristics of these systems allow users to create long-haul systems. If unlicensed user interference threatened the integrity of these networks, *Coalition* members would have no viable alternative to their existing 6 GHz networks.

The 11 GHz and 18 GHz bands are not suitable alternatives because they do not provide acceptable transmission characteristics to link substations that are hundreds of miles apart without an excessive number of repeater locations. Links in these bands tend to be shorter, which would require additional sites to be built at tremendous cost, which is not financially feasible for utility rate payers, and physically impossible for some sites. For example, 11 GHz hops are typically about 20 miles apart and 6 GHz hops can be placed up to 60 miles apart. One *Coalition* member maintains a reliable 6 GHz hop that is 79 miles long. The 18 GHz band supports hops that are typically only four to five miles apart. Multiple *Coalition* members estimated that it would cost at least $1 million per hop to replace existing 6 GHz system with a

fixed point-to-point system operating in the 11 GHz band. In addition, fiber alternatives are not financially feasible, and may be physically impossible due to the terrain. These links cover tens of thousands of miles.

Ultimately, the 6 GHz band was intentionally selected by *Coalition* licensees because of its protection and propagation characteristics. Some of the *Coalition* members landed in the 6 GHz band after systems that relied on other unlicensed bands were inoperable due to harmful interference. Private operational fixed microwave licensees have been required to vacate both the 1.9 GHz band and the 2.1 GHz band so the Commission could reallocate the spectrum.[7] This proceeding is another attempt to compromise the integrity of a longstanding critical infrastructure spectrum allocation that is vital to the continuing safe operation of these companies underlying businesses. Unlicensed users should be not introduced into the band without adequate protection for incumbent licensees.

D. The FCC Should Establish Rules Which Protect Incumbent 6 GHz Fixed Licensees from Interference

i. Outages

The *Coalition* understands that the Commission intends to make new frequency bands available for wireless broadband services, but it should not do so at the expense of the nation's critical infrastructure networks. The FCC's proposed rule changes pose a threat not only to the *Coalition's* private 6 GHz networks, but also to the common carrier networks that many *Coalition* members rely on to supplement internal operations.[8] Outages to the *Coalition's*

[7] *See*, Redevelopment of Spectrum to Encourage Innovation in the Use of New Technologies, 7 FCC Rcd. 6886 (1992). The deadline for licensees to relocate from the 2.1 GHz Band is 2016. *See*, Service Rules For Advanced Wireless Services, 17 FCC Rcd 24135 ¶43 (2002).

[8] A Universal Licensing System search on February 11, 2019 showed that AT&T, Verizon, and CenturyLink collectively hold more than 4,200 licenses authorizing fixed operations in the 6 GHz band.

existing 6 GHz systems are rare. Any rule changes proposed by the FCC should ensure this does not change. The FCC should adopt rules which prevent unlicensed users in the band from even slightly increasing the incidence of those outages. The *Coalition* agrees with the Fixed Wireless Communications Coalition ("FWCC") that the Commission should adopt rules which limit additional outages caused by unlicensed users in the band to no more than 3 seconds per year per incumbent fixed licensee receiver.[9]

ii. Protection Criteria

The Commission sought comment on the interference protection criteria that should be adopted to determine whether an unlicensed device could cause harmful interference to a fixed link receiver.[10] The NPRM specifically suggested an interference protection criterion of zero dB (interference to noise power).[11] The *Coalition* agrees with FWCC's proposal that an interference criterion of 1 dB fade margin degradation (I/N = -6 dB) should be adopted. This would promote the Commission's most important goal of ensuring that these incumbent operations that fuel the nation's economy are not impacted by the introduction of unlicensed devices in this band.

iii. Frequency Coordination

The Commission should require prior coordination for all indoor and outdoor unlicensed operations. The FWCC has explained to the Commission that unlicensed devices cannot reliably determine outdoor clutter or indoor elevation. The best – and perhaps only – way to avoid harmful interference to incumbent fixed licensees is to require unlicensed devices to operate through a coordination system that locks out unlicensed devices that operate on the same channel

[9] FWCC July 17, 2018 *Ex Parte*, at 7.

[10] *NPRM* at ¶43.

[11] *Id.*

(co-frequency) or an adjacent frequency to a licensed, fixed receiver, and within the 1 dB exclusion zone under line-of-sight assumptions at any elevation.[12]

The Commission proposes to permit operation of unlicensed devices in the U-NII-5 and the U-NII-7 bands on frequencies determined by an automated frequency coordination ("AFC") system.[13] The Commission's comparison between the AFC process (which is untested on a large-scale) and the well-established frequency coordination process (which all fixed licensees must go through prior to licensing) is inapposite.

For one, licensees of 6 GHz spectrum must go through a Prior Coordination Notice ("PCN") period following frequency coordination to allow other nearby incumbent licensees the opportunity to object before the new or modified system can be placed on the air. As the Commission has noted time and again, "all applicants and licensees have a fundamental duty to work with each other in the frequency coordination process."[14] The PCN is essential to that process, which requires an applicant to affirmatively contact other licensees and applicants prior to filing an application with the Commission.[15]

A traditional PCN requires a 30-day waiting period, during which, "[e]very reasonable effort should be made by all applicants, permittees and licensees to eliminate all problems and conflicts."[16] An expedited PCN of as little as 14 days also is available. For an expedited PCN, the requesting party must receive written concurrence (or verbal concurrence, with written

[12] FWCC July 17, 2018 *Ex Parte*, at 13. The FWCC's mitigation proposal assumes zero ground clutter and a worst-case elevation any unlicensed device location.

[13] *NPRM* at ¶22.

[14] Wireless Telecommunications Bureau's Broadband Division and Public Safety and Homeland Security Bureau's Policy and Licensing Division Issue Declaratory Ruling on Microwave Frequency Coordination and Seek Comment on Portion of Petition for Declaratory Ruling Filed by the Fixed Wireless Communications Coalition, Inc., *Public Notice*, 30 FCC Rcd 335 at 3 (2015) ("*FWCC Declaratory Ruling PN*").

[15] *Id*. at 4.

[16] 47 C.F.R. § 101.103(d)(2)(iv).

concurrence to follow) from affected parties."[17] The responsibility to receive concurrence is on the notifying party, and if an applicant or licensee is unable to timely respond to a request for expedited coordination, the applicant or licensee must inform the notifying party that more time is needed. The Commission has taken a strict approach to protecting incumbents during this process, stating, "absent extraordinary circumstances, the party submitting the PCN must accommodate that request for additional time."[18]

The PCN is also the primary function for allowing incumbent microwave licensees to object to an application for new or modified authority. In 1996, a statutory amendment removed private fixed point-to-point microwave applications from Section 309(b) of the Communications Act, which lists the kinds of applications subject to the 30-day public notice period.[19] The FCC's intent was to provide expedited licensing for private fixed point-to-point microwave applications.[20] As a result, "the only option for a party who wishes to challenge a [private operational fixed service] application prior to action on that application is to file an information objection."[21] It is hard to imagine an AFC system affording incumbent, fixed, point-to-point licensees with the same level of protection.

The Commission referenced the TV White Space and Citizens Broadband Radio Service ("CBRS") as examples where AFC systems have been deployed. The Commission's TV White Space proceeding was established in 2004 to examine the band for unlicensed use. Fourteen

[17] *FWCC Declaratory Ruling PN* at 3.

[18] *Id.*

[19] Geodesic Networks, LLC, *Memorandum Opinion and Order and Order on Reconsideration*, 29 FCC Rcd 10429 (WTB BD 2014) at 11, *citing* 47 C.F.R. § 1.933(d)(9).

[20] *Id.*

[21] Wireless Telecommunications Bureau's Broadband Division and Public Safety and Homeland Security Bureau's Policy and Licensing Division Issue Declaratory Ruling on Microwave Frequency Coordination and Seek Comment on Portion of Petition for Declaratory Ruling Filed by the Fixed Wireless Communications Coalition, Inc., *Public Notice*, 30 FCC Rcd 335 at 5 (2015).

years later, the Commission is still being urged to resolve the Database Accuracy proceeding to adopt technical rules associated with the band.[22] The CBRS band is not yet operational. No database manager has implemented the AFC systems that the band will ultimately rely on, so it is premature to tout that as a success that should be replicated in other bands. Regardless, the Commission speculated in the NPRM that an AFC system could be "easy to implement."[23]

If the Commission proceeds, it should require any AFC database system for both indoor and outdoor unlicensed devices to maintain secure communications between unlicensed devices and the databases, as well as secure communications among the databases. All information that is required by the Commission's rules to be in the AFC databases should be publicly available.

The NPRM noted that AFC systems should be designed to ensure that unlicensed operations protect new and modified licensed operations.[24] Any such system should also be designed to ensure that systems operating under Special Temporary Authority ("STA")[25] and Conditional Temporary Authority ("CTA") are also protected, consistent with the Commission's rules.

CTA in the 6 GHz band is authorized upon the submission of a completed FCC Form 601 application that has successfully completed the frequency coordination procedures and that does not involve a request to waive any of the Commission's rules.[26] Because the FCC's processing time for point-to-point microwave applications fluctuates, *Coalition* members may rely on CTA

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[22] *See* Letter from Sen. Daines and Sen. Johnson to FCC Chairman Pai, Nov. 27, 2018 (available at: https://www.daines.senate.gov/imo/media/doc/Daines%20Johnson%20Letter%20to%20FCC%20regarding%20TVWS%20proceedings%2011.27.18.pdf).

[23] *NPRM* at ¶25.

[24] *NPRM* at ¶29.

[25] Applications for STA in the Private Wireless Services for periods less than 180 days do not require coordination and are authorized on a secondary, non-interference basis. 47 C.F.R. § 1.931(b).

[26] 47 C.F.R. 101.31(b).

to begin operating systems during the pendency of applications. Because licensees may rely on CTA to begin operating immediately after filing certain applications with the Commission, it is critical that pending applications be afforded the same level of protection as that given to fully licensed systems in the Commission's database.

The Commission also proposed that devices periodically be required to verify whether frequency availability has changed and requested comment on the maximum permissible interval for verifying frequency availability.[27] At a minimum, any unlicensed device should verify whether frequency availability has changed at least twice daily, to account for technical changes to licensed systems. As the FWCC has pointed out, relying on the data in the Universal Licensing System ("ULS") alone is inadequate.[28] However, in an effort to encourage licensees to update the ULS database, the *Coalition* supports FWCC's suggestion of amnesty on filings for Part 101 ULS corrections.[29] In addition, the *Coalition* recommends that any AFC system that is developed for 6 GHz unlicensed devices should be tested in geographically limited areas with limited numbers of unlicensed devices and ultimately deployed on a gradual basis to allow any and all interference concerns to be alleviated before such devices can cause serious harm to incumbent 6 GHz licensees.

[27] *NPRM* at ¶30.

[28] FWCC October 2, 2018 *Ex Parte* at 2.

[29] *Id.*

III. CONCLUSION

WHEREFORE, THE PREMISES CONSIDERED, the *Critical Infrastructure Coalition* urges the Commission to act in a manner consistent with the views expressed herein.

Respectfully submitted,

CRITICAL INFRASTRUCTURE COALITION

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EXHIBIT A

The following is a brief description of each *Coalition* member.

MidAmerican Energy Company provides service to 770,000 electric customers and 751,000 natural gas customers in a 10,600-square mile area in Iowa, Illinois, South Dakota and Nebraska.

PacifiCorp serves approximately 1.9 million customers in Oregon, Washington, California, Utah, Wyoming, and Idaho.

NV Energy has a service area that covers 46,000 square miles including Las Vegas and Reno, Nevada. The company provides energy services to 1.3 million customers and more than 40 million tourists annually, and natural gas to more than 160,000 customers. MidAmerican Energy Company, PacifiCorp, and NV Energy are subsidiaries of Berkshire Hathaway Energy.

Black Hills Corporation serves 1.2 million natural gas and electric customers in Arkansas, Colorado, Iowa, Kansas, Montana, Nebraska, South Dakota, and Wyoming.

Salt River Project provides electricity to approximately 1 million retail customers in a 2,900-square-mile service area in Arizona. Salt River Project's water business delivers 800,000 acre-feet of water annually to a 375-square-mile service area and manage a 13,000-square-mile watershed that includes an extensive system of reservoirs, wells, canals, and irrigation ditches.

Exxon Communications Company is a license-holding subsidiary of Exxon Mobil Corporation. Exxon Mobil Corporation is the world's largest publicly traded international oil and gas company, which includes business lines in crude oil, asphalt, industrial lubricants, and chemical processing and refining, among many others.

NorthWestern Energy has provided reliable and affordable energy to customers in Montana, South Dakota and Nebraska for more than 100 years. The company provides electricity and natural gas to more than 718,300 residential and business customers using 28,055 miles of electric transmission and distribution lines, and 9,758 miles of natural gas lines. The company also owns 11 hydroelectric dams.

Enterprise Products Partners L.P. is a leading North American provider of midstream energy services to producers and consumers of natural gas, natural gas liquids, crude oil, refined products and petrochemicals. Enterprise's services include natural gas gathering, treating, processing, transportation and storage; natural gas liquids transportation, fractionation, storage and import and export terminals; crude oil gathering, transportation, storage and terminals; petrochemical and refined products transportation, storage and terminals; and a marine transportation business that operates primarily on the United States inland and Intracoastal Waterway systems. The company operates approximately 50,000 miles of natural gas, natural gas liquids, crude oil, refined products, and petrochemical pipelines. Enterprise Products also operates 260 million barrels of natural gas liquids, refined products, and crude oil storage capacity, and 14 billion cubic feet of natural gas storage capacity.

GeoSouthern Energy Corporation is an independent oil & gas producing company specializing in the production of Austin Chalk and Eagle Ford unconventional formations. The company produces oil and gas and has substantial acreage positions in Gonzales and Lavaca counties in Texas.

Louisville Gas and Electric Company and **Kentucky Utilities Company** are subsidiaries of PPL Corporation. Louisville Gas and Electric Company serves 411,000 electric customers and 326,000 natural gas customers in Louisville, Kentucky and its 16 surrounding

counties. Kentucky Utilities Company serves 553,000 electric customers in Kentucky, Virginia, and Tennessee.

Marathon Oil Corporation is an independent exploration and production company focused on U.S. unconventional resource plays. The company's most significant oil-rich resource plays in the U.S. are located in the Eagle Ford in Texas; the Bakken in North Dakota; STACK and SCOOP in Oklahoma; and the Permian in New Mexico. Marathon Oil's average net production across all U.S. resource plays in the fourth quarter of 2018 was 295,000 barrels of oil equivalent per day.

Occidental Petroleum Corporation is one of the largest operators and oil producers in the Permian Basin, producing approximately 9 percent of the total oil in the basin. With nearly 2.5 million net acres, Occidental produces from every producible formation in the Permian Basin. Occidental's Permian oil and gas production accounted for nearly 50 percent of our 2017 total ongoing worldwide production. Occidental's midstream and marketing segment gathers, processes, transports, stores, purchases and markets oil, condensate, natural gas liquids (NGLs), natural gas, carbon dioxide (CO_2) and power.